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**(56) Documents Cited**

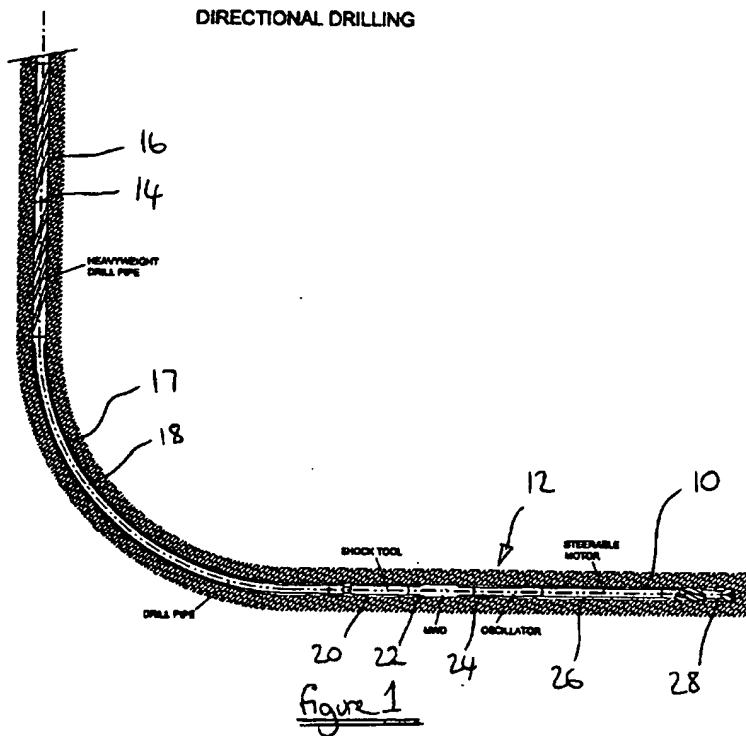
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**(58) Field of Search**

UK CL (Edition Q ) E1F FAW FDD FEH FGL  
INT CL<sup>6</sup> E21B

(54) Abstract Title  
Drilling method

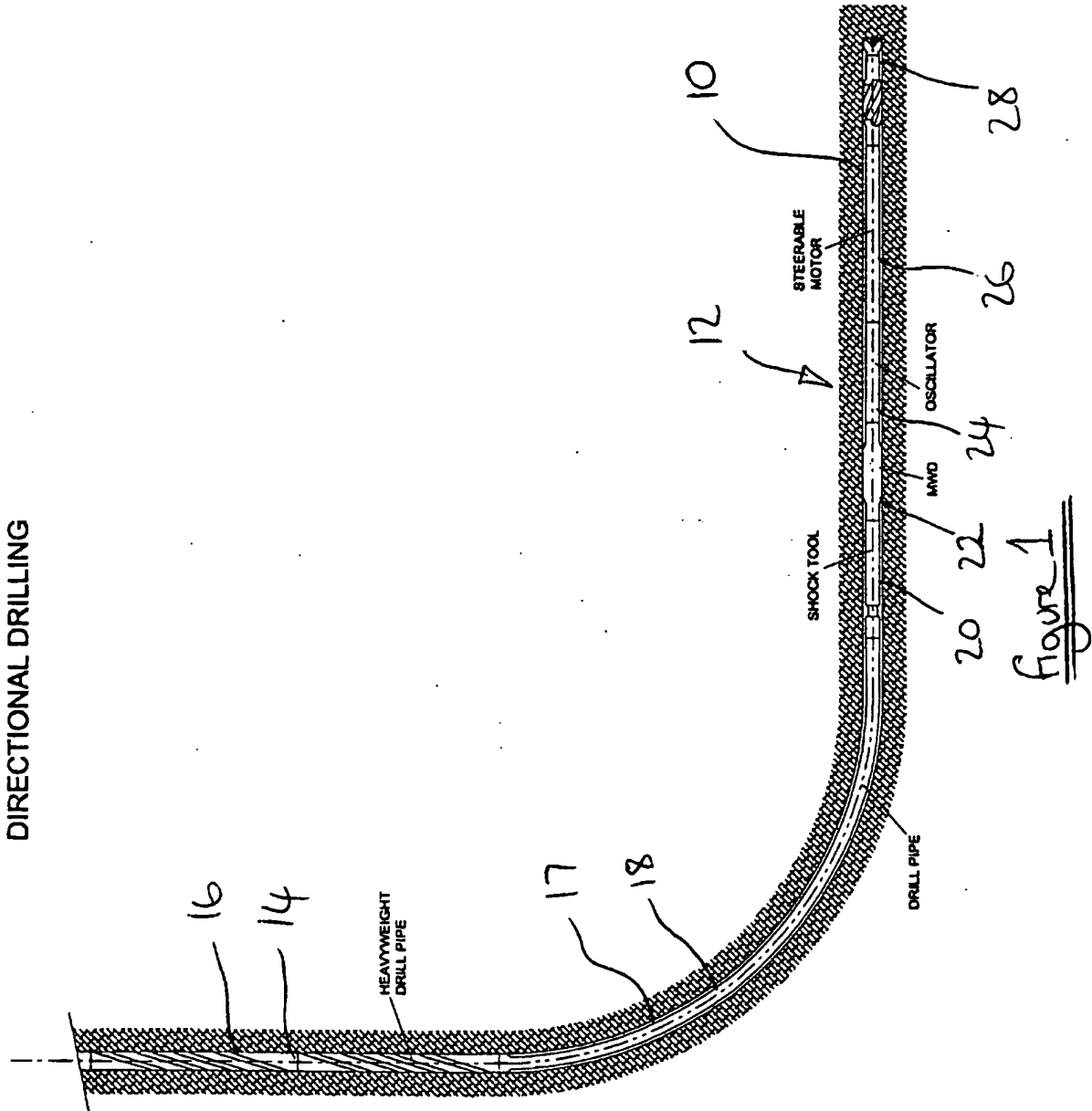
(57) A method of drilling a bore 10 comprises providing a drill support 14, 18, coupling a drill bit 28 to the end of the drill support to form a drill string, running the string downhole, and applying an oscillating force to a portion of the drill string to reduce the friction between the drill string and the bore wall and to facilitate advancement of the string through the bore.



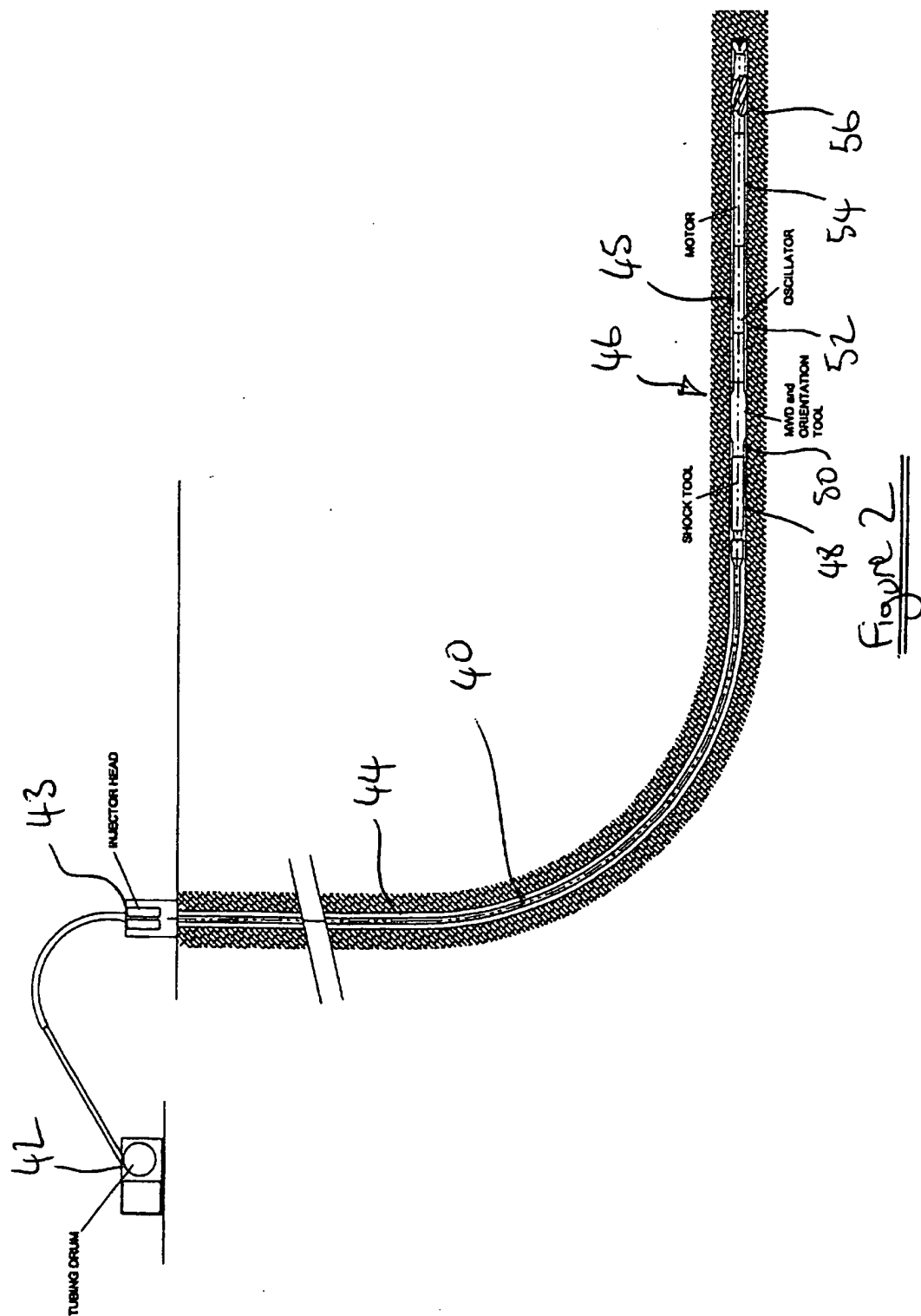
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# DIRECTIONAL DRILLING



# COILED TUBING DRILLING



DRILLING METHOD

This invention relates to drilling methods, and in particular but not exclusively to drilling operations where a relatively low weight is applied to the drill bit, such as in coiled tubing drilling, and drilling operations where the drill bit support is not subject to rotation, such as in directional drilling utilising sliding steerable downhole motors.

In directional drilling operations, a steerable downhole motor incorporating an elbow or bent housing may be provided on the lower end of a drill string. When the entire drill string is driven from the surface, the effect of the elbow is negated and has the result that the drill bit essentially drills straight ahead. However, if the drill string is held in a particular orientation and the steerable downhole motor utilised to rotate the bit, the slight deviation introduced by the elbow is retained as the drill bit advances, producing a deviating bore. One of the main problems encountered while drilling in this manner is the difficulty of progressing the string through the bore: when the string is rotating, it is relatively easy to push the string through the bore, however in the absence of such rotation the bit tends to move in a "stick-slip" progression. The static friction between the string and the bore may prevent advancement of the bit, and the weight on the bit is increased to overcome this friction. Once

the static friction is overcome, the lower dynamic friction allows the string to move or slip forward, often quite rapidly. This results in a large shock load being applied to the bit, which load will often result in the downhole motor stalling, requiring retraction of the bit to restart the motor.

In coiled tubing drilling, weight for application to the drill bit may be produced by locating masses on the tubing. However, in many instances, and in particular in inclined and horizontal bores, attempts are often made to apply weight from the surface. Typically, this has the effect of deforming the coiled tubing into a corkscrew-like form, and has little if any useful effect.

It is among the objectives of embodiments of the present invention to obviate or mitigate these disadvantages.

According to the present invention there is provided a method of drilling a bore, the method comprising:

providing a drill support having a proximal end and a distal end;

coupling a drill bit to the distal end of the drill support to form a drill string;

running the string downhole; and

applying an oscillating force to a portion of the drill string spaced from the proximal end of the string to reduce the friction between the drill string and the bore wall and facilitate advancement to the string through the bore.

According to another aspect of the present invention there is provided apparatus for use in drilling a bore, the apparatus comprising:

5 a drill support having a proximal end and a distal end;

a drill bit for coupling to the distal end of the drill support to form a drill string; and

means spaced from the proximal end of the drill string for applying an oscillating force to a portion of the drill string, to reduce the friction between the drill string and the bore wall and facilitate advancement to the string through the bore.

The invention also relates to an apparatus for location in a drill string, drill support or bottom hole assembly (BHA) for creating an oscillating force to facilitate sliding movement of a drill string in a bore. The force may be created internally of the string, or may be arranged to act on the bore wall to, for example, induce transverse or rocking movement of the string relative to the bore.

Although not wishing to be bound by theory, it is believed that the substantially continuous movement of the string or at a portion of the string, induced by the application of the oscillating force, is such that advancement of the bit only requires the dynamic friction between the string and the bore wall to be overcome. Thus, the string may be advanced by application of a relatively low axial force. Accordingly, the invention has particular

application in drilling operations in which the drill bit is not driven from the surface, that is in operations in which the drill string does not rotate, such as directional drilling utilising a downhole motor incorporating an elbow.

5 Further, the invention is also useful in applications where the nature of the drill support is such that it does not permit the transfer of substantial axial forces, such as coiled tubing or small diameter drill pipe. The invention may also be useful when tripping a drill string in to or  
10 out of a bore, particularly from an inclined bore or a bore that has become restricted by deposits such as sand or drill cuttings, as the vibration induced by the oscillating force will tend to fluidise or dislodge the deposits.

A large number of prior proposals have been made of  
15 arrangements which seek to apply a percussive force to a drill bit, or produce a pulsing fluid flow from the drill bit, and so increase drilling rate, the prior arrangements principally finding application in conventional "vertical" drilling utilising drill pipe rotated from surface. None  
20 of these earlier proposals recognise that the provision of an oscillating force can significantly reduce the friction experienced by a drill string sliding through a bore, however it is possible that adaptations of many of these prior proposals may be usefully employed in the present  
25 invention.

Preferably, the oscillating force is substantially axial, although the force may be substantially transverse or include a substantial transverse element.

Preferably also, the oscillating force is produced by restricting the flow of drilling fluid through the string, it being believed that the restriction in flow creates one or both of a pressure force and an impulse force on the string, resulting from the loss of momentum in the drilling fluid, which force will also tend to "push" or "pull" the string through the bore. The restriction may be produced by operation of a valve, located in the string bore. The valve may include an axially oscillating valve member, and in the preferred embodiment include a rotating valve member, which may be driven by a drilling fluid actuated motor. The present invention may incorporate motor and valve arrangements such as described in the applicant's earlier patent applications, that is PCT/GB98/01170 and WO97/44565, the disclosures of which are incorporated herein by reference. In other embodiments it may be possible to drive the valve member using other means, such as an electric motor powered from the surface using a conductor extending through the string. The valve may be provided in combination with a shock sub or tool. The shock tool may be utilised to at least partially isolate the oscillating portion of the string, typically the BHA, from the remainder of the string, and may also assist in permitting oscillation of the BHA; if there was a rigid connection between the BHA and the remainder of the string, the very significant inertia of the string would tend to resist the movement that the oscillating force is intended to induce.

In other embodiments the oscillating force may be produced by a reciprocating mass, movement of the mass being induced by, for example, forces produced by movement of drilling fluid through or around the mass, such as described in our UK Patent Application No 9726204.2, or by a motor rotating or otherwise moving the mass. The mass may also be spring mounted.

Where the means for providing the oscillating force is motor-driven, the motor may be provided above or below said means, or may be incorporated within said means.

The rate or frequency of oscillation may be selected following testing and may be controlled by any appropriate means, including drilling fluid flow rate, electrical power input to a valve or mass actuating motor, spring rate, damping, and the mass of any oscillating or reciprocating parts.

The presence of the oscillating force may also increase drilling rates by providing a percussion effect at the drill bit.

Preferably also, the oscillating force is created adjacent the distal end of the drill string and the drill bit, in or adjacent to the bottom hole assembly (BHA). In some embodiments the oscillating force may be transferred to the drill bit, but it is not believed that this is necessary to obtain the benefit of the present invention. In other embodiments the oscillating force may be created at a location spaced from the BHA, for example at a location where there is likely to be relatively high

friction between the string and the bore wall, such as at an inclined or horizontal section of the bore. Of course an oscillating force may be created at a plurality of locations on the string.

5        These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

10        Figure 1 is a schematic illustration of a directional drilling operation, in accordance with a first embodiment of the present invention; and

Figure 2 is a schematic illustration of a coiled tubing drilling operation in accordance with a second embodiment of the present invention.

15        Reference is first made to Figure 1 of the drawings, which illustrates a directional drilling operation in accordance with a preferred embodiment of the present invention. The Figure illustrates the drilling of a horizontal section of bore 10, and a bottom hole assembly (BHA) 12 mounted to the lower or distal end of a drill support comprising sections of heavyweight drill pipe 14, 20        for location in a vertical section of the bore 16, and sections of more flexible drill pipe 18 for location in the bore section 17 where the bore deviates from the vertical. Those of skill in the art will of course identify that the 25        illustration is much simplified and that the bore deviation has been greatly exaggerated.

The BHA 12 comprises, from the distal end of the drill pipe section 18, a shock tool 20, a measurement while

drilling (MWD) tool 22, an oscillator 24, a steerable motor 26, and a stabilised drill bit 28. The shock tool 20, MWD tool 22, steerable motor 26 and bit 28 are substantially conventional. The oscillator 24 may take many forms, and in this example comprises a drilling mud driven positive displacement motor and a valve driven by the motor to define a varying mud flow area. In use, flow of drilling mud through the oscillator 24 drives the motor which in turn drives the valve. The variation in flow area through the valve results in a variation in the mud flow rate through the valve and at least a partial interruption in the mud flow, producing an impulse on the valve and a pressure increase in the mud above the valve. The mud pressure increase results in a tendency for the shock tool 20 to extend and this, combined with the impulse on the valve, induces axial movement of the BHA 12, the shock tool 20 also tending to isolate the movement from the drill pipe sections 14, 18.

In use, drilling will normally be accomplished by rotating the drill string from the surface. In this situation the drill bit 28 will tend to drill straight ahead. However, if it is desired to alter the course of the bore, rotation of the string is halted, and the string then rotated slowly to direct the steerable motor 26, which incorporates a 1° elbow, in the desired direction, as identified by the MWD tool 22. Mud is then pumped through the non-rotating string to drive the motor 26 and rotate the bit 28. The mud flow also drives the motor in the

oscillator 24, causing the BHA 12 to oscillate axially. The oscillation or vibration of the BHA 12 facilitates sliding movement of the BHA 12 as the bit 28 advances.

5 It is believed that the vibration and movement induced in the BHA 12 results in a significant reduction in friction between the BHA 12 and the bore wall, and in particular only requires that dynamic friction be overcome, as opposed to the static friction which must be overcome in the "stick-slip" progress of a conventional BHA in these  
10 circumstances. Thus, the drilling rate is improved and directional drilling becomes possible in many situations in which conventional directional drilling would not be available.

Reference is now made to Figure 2 of the drawings,  
15 which illustrates a coiled tubing drilling operation in accordance with a second embodiment of the present invention. The Figure shows coiled tubing 40 being supplied from a tubing drum 42 on the surface and passed into a bore 44 via an injector head 43. Mounted on the  
20 lower or distal end of the tubing 40, in a horizontal bore section 45, is a bottom hole assembly (BHA) 46 comprising a shock tool 48, a MWD and orientation tool 50, an oscillator 52, a motor 54 and a drill bit 56.

During a drilling operation the drill bit 56 is  
25 rotated by the mud-driven motor 54, the BHA 46 advancing under the influence of the weight on the non-rotating tubing 40 and any weight applied to the tubing at the surface via the injector head 43. However, only a modest

axial force may be applied to the tubing 40 before the tubing will begin to deform.

In this embodiment the drilling direction is determined by the MWD and orientation tool 50, the bit advancing by sliding movement of the BHA 46.

In this example the oscillator 52 comprises an electric motor, connected to a power supply by a conductor passing through the tubing 40, for driving a mud flow-controlling valve positioned above a spring mounted mass defining a through bore and orifice. In use, the motor drives the valve to vary the mud flow rate through the mass, the varying pressure force across the mass orifice inducing axial oscillation of the mass. As with the first-described embodiment, this induces a corresponding oscillation or movement of the BHA 46, facilitating advancement of the bit 56, without the requirement to apply excessive weight to the tubing 40.

It should be noted that the particular relative positioning of the components of the BHAs 12, 46 described above is exemplary, and may be changed as desired or as required. Also, in other embodiments, the oscillation or vibration may not be isolated from the remainder of the string by means of a shock tool or the like, and indeed one or more oscillators may be provided at other locations on the string.

Those of skill in the art will recognise that the above-described embodiments are merely exemplary of the present invention and that various modifications and

improvements may be made thereto without departing from the scope of the present invention.

CLAIMS

1. A method of drilling a bore, the method comprising:  
providing a drill support having a proximal end and a  
distal end;  
5 coupling a drill bit to the distal end of the drill  
support to form a drill string;  
running the string downhole; and  
applying an oscillating force to a portion of the  
drill string spaced from the proximal end of the string to  
10 reduce the friction between the drill string and the bore  
wall and facilitate advancement to the string through the  
bore.
2. The method of claim 1, wherein the string is advanced  
by sliding movement.
- 15 3. The method of claim 1 or 2, wherein the drill bit is  
driven by a downhole motor.
4. The method of claim 3, wherein the drill is driven by  
a downhole motor incorporating an elbow.
5. The method of any of the preceding claims, further  
20 comprising applying said oscillating force while one of  
tripping a drill string in to and out of a bore.

6. The method of claim 5, wherein the vibration induced by the oscillating force is utilised to fluidise or dislodge the deposits lying in the bore.

7. The method of any of the preceding claims, wherein  
5 the oscillating force is substantially axial relative to the drill support.

8. The method of any of the preceding claims, wherein oscillating force is produced by selectively restricting the flow of drilling fluid through the string.

10 9. The method of any of the preceding claims, further comprising at least partially isolating the oscillating portion of the string from the remainder of the string.

10. The method of any of the preceding claims, wherein the oscillating force is created adjacent the distal end of the  
15 drill string and the drill bit.

11. The method of any of claims 1 to 9, wherein the oscillating force is created at a location spaced from the distal end of the drill string.

12. The method of any of the preceding claims, wherein an  
20 oscillating force is created at a plurality of locations on the string.

13. Apparatus for use in drilling a bore, the apparatus comprising:

a drill support having a proximal end and a distal end;

5 a drill bit for coupling to the distal end of the drill support to form a drill string; and

means spaced from the proximal end of the drill string for applying an oscillating force to a portion of the drill string, to reduce the friction between the drill string and the bore wall and facilitate advancement to the string through the bore.

10 14. The apparatus of claim 13, further comprising a downhole motor incorporating an elbow.

15 15. The apparatus of any claim 13 or 14, wherein the drill support is in the form of coiled tubing or small diameter drill pipe.

16. The apparatus of claim 13, 14 or 15, wherein said means includes means for restricting the flow of drilling fluid through the string.

20 17. The apparatus of claim 16, wherein the flow restricting means includes a valve located in a string bore.

18. The apparatus of claim 17, wherein the valve includes

an axially oscillating valve member.

19. The apparatus of claim 17, wherein the valve includes a rotating valve member.

20. The apparatus of claim 19, wherein further comprising  
5 a drilling fluid actuated motor for driving the valve member.

21. The apparatus of any of claims 13 to 20, further comprising a shock tool for to at least partially isolating the oscillating portion of the string from the remainder of  
10 the string.

22. The apparatus of any of claims 13, 14 or 15, wherein said means includes a reciprocating mass.

23. The apparatus of claim 22, wherein the mass is spring mounted.

15 24. The apparatus of any of claim 13 to 23, wherein said means for providing the oscillating force is located adjacent the distal end of the drill string and the drill bit, in or adjacent to a bottom hole assembly (BHA).

20 25. Apparatus for location in one of a drill string, drill support or bottom hole assembly (BHA), the apparatus including means for creating an oscillating force to facilitate sliding movement of a drill string in a bore.



Application No: GB 9822767.1  
Claims searched: 1-25

Examiner: David Pepper  
Date of search: 13 September 1999

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): E1F FAW, FDD, FEH, FGL

Int Cl (Ed.6): E21B

Other:

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
X,E	GB 2332690 A (Doig et al) - see p 20, line 25 to p 21, line12	1,25
X	GB 2329408 A (Bakke Oil Tools) - whole document	1-25
X	GB 2318374 A (Baker Hughes) - see p 21, line 22 to p 22, line 27	1-25
X	GB 2293839 A (Paterson) - whole document	1-25
X	GB 2272924 A (BP Chemicals) - whole document	1,25
X	GB 2261238 A (BP Exploration) - whole document	1-25
X	EP 0304988 A (Shell Internationale) - see col 4, lines 41- 48	1-25
X	EP 0245892 A (Shell Internationale) - whole document	1-25
X	WO 97/46787 A (RF-Procom) - whole document	1-25
X	US 4384625 A (Mobil Oil) - whole document	1-25

X Document indicating lack of novelty or inventive step  
Y Document indicating lack of inventive step if combined with one or more other documents of same category.  
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A Document indicating technological background and/or state of the art.  
P Document published on or after the declared priority date but before the filing date of this invention.  
E Patent document published on or after, but with priority date earlier than, the filing date of this application.